

An Operational Real-Time Eddy-Resolving 1/16° Global Ocean Nowcast/Forecast System

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Planning Systems Inc.**

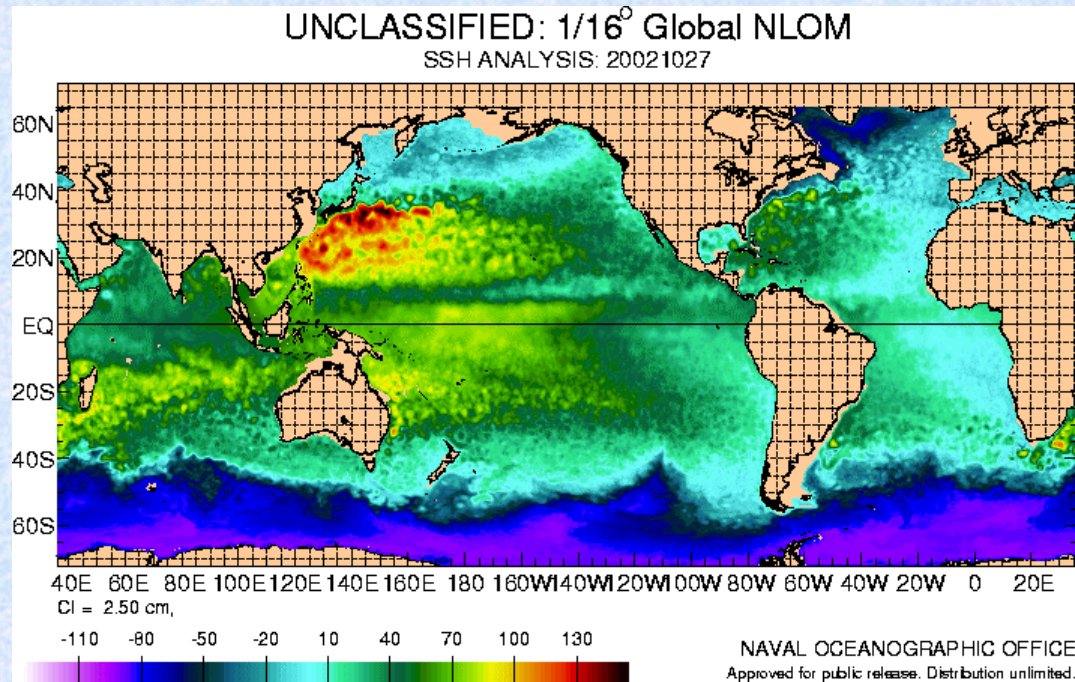
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Naval Research Laboratory**

**A. B. Kara
Florida State University**

**C. P. Murray
Naval Oceanographic Office**

http://www.ocean.nrlssc.navy.mil/global_nlom

1/16° NLOM SSH on 27 October 2002



- **1/16° Near Global NRL Layered Ocean Model (NLOM)**
- **7 layers including an embedded mixed layer model**
- **NOGAPS wind stress and thermal forcing**
- **Assimilation of SSH from ERS-2 and GFO and SST from daily MODAS 2-D SST analysis. Jason-1 and Envisat will be added as soon as the data are available from the Altimeter Data Fusion Center (ADFC) at NAVOCEANO**

Data Assimilation Methodology

Ol deviation analysis using the model as first guess

- Mesoscale data covariance from T/P + ERS-2 data calculated by Jacobs et al. (2001, JGR-O)
- 3-day window for altimeter data

Subsurface statistical inference via EOF regression

- Including the abyssal layer which has a major impact on the upper ocean circulation, Hurlburt et al. (1990, JGR-O)

Velocity changes via geostrophy

- Outside of equatorial band

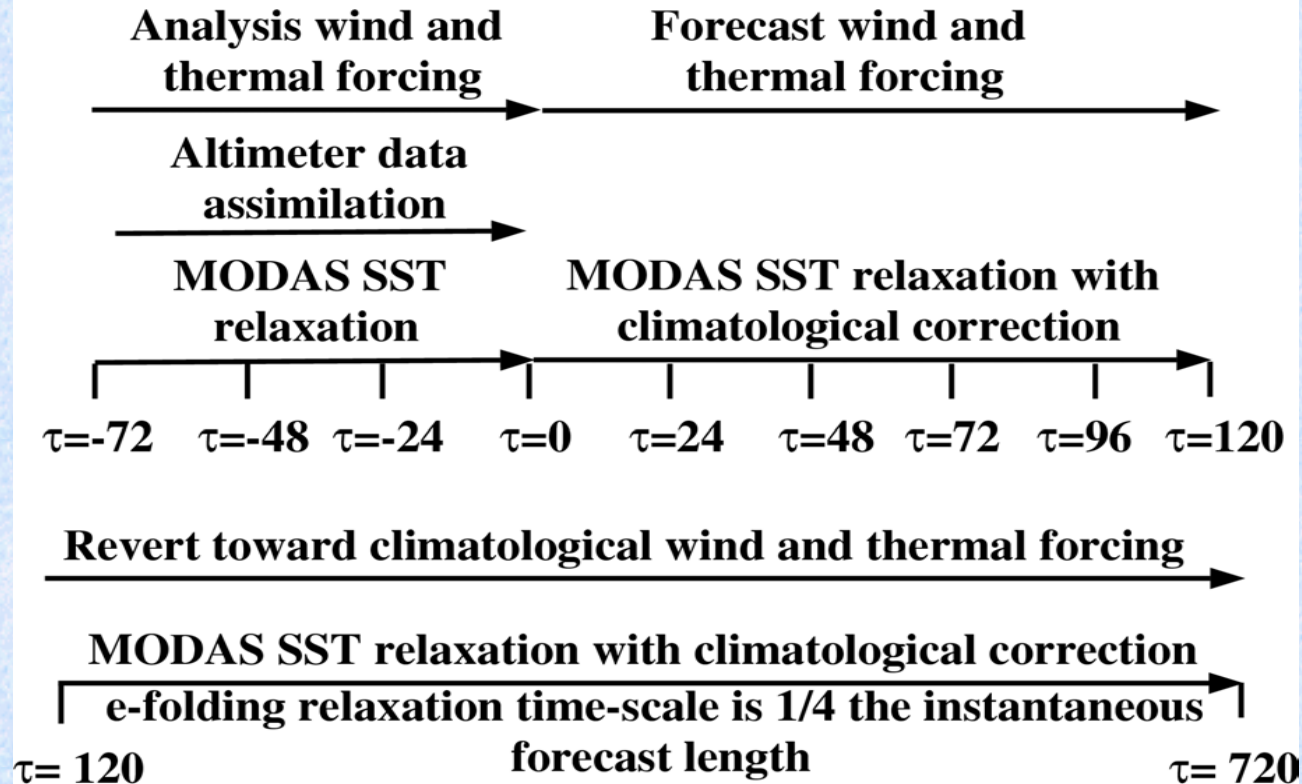
Incremental updating to minimize gravity wave generation

Assimilation cycles need to go back approximately 3 days to pick up altimeter data with improved orbit removal

- More recent altimeter data with less accurate orbits are also used

Relaxation to the daily MODAS SST analysis

Operational NLOM cycle



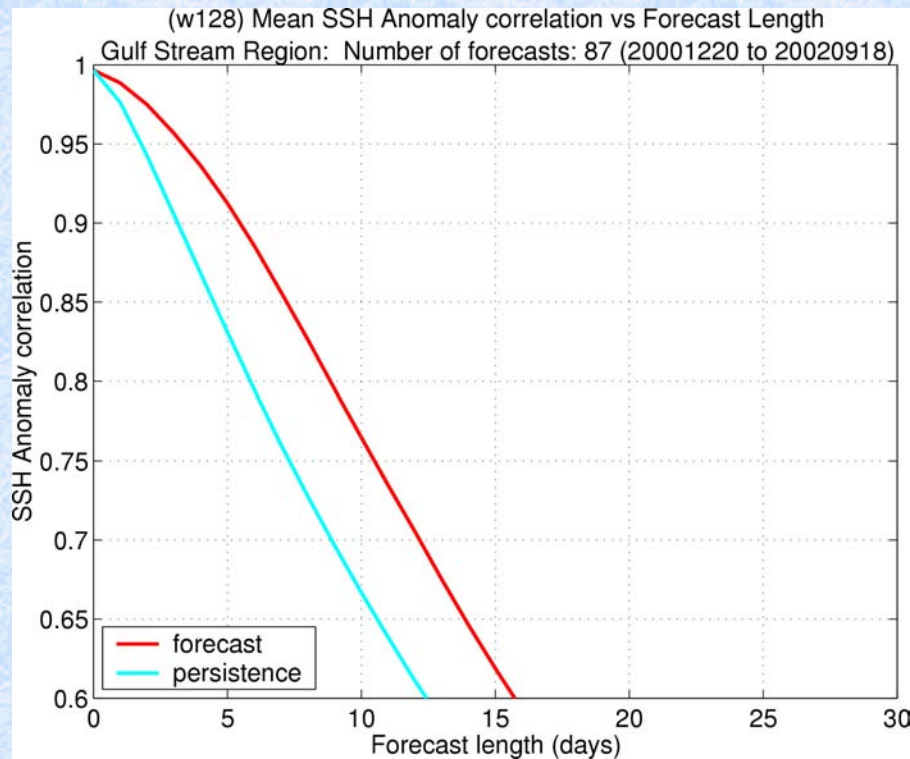
30 day forecast every Wednesday

- **NLOM has been running in real time at NAVOCEANO since 18 October 2000**
- **NLOM became an operational product on 27 September 2001**

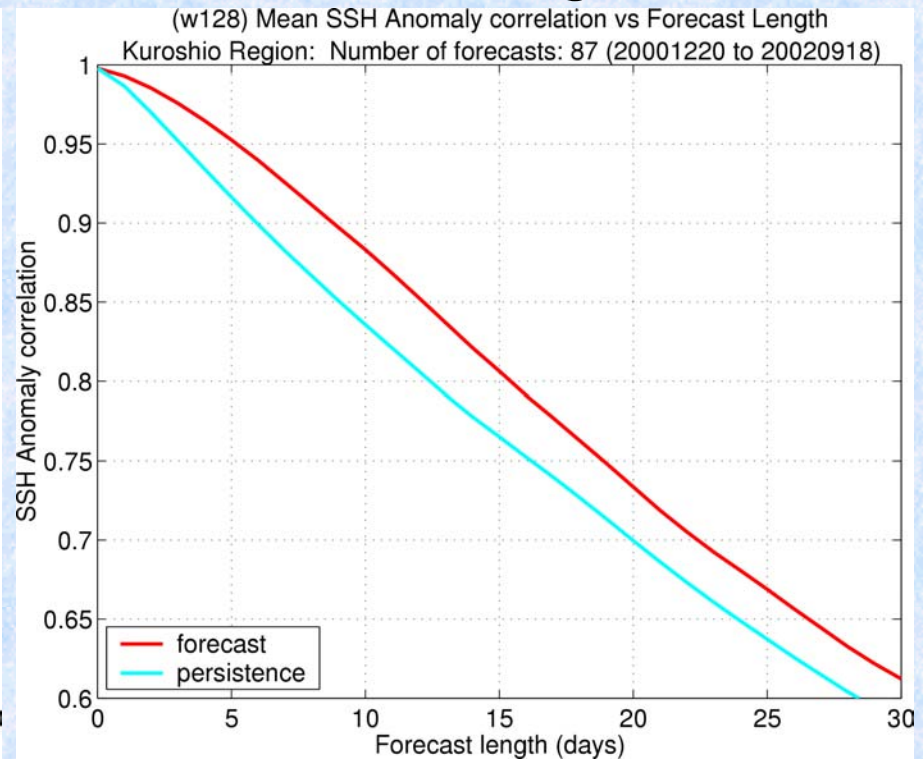
1/16° Global NLOM Forecast Skill

SSH Anomaly Correlation (mean over 87 forecasts)

Gulf Stream Region



Kuroshio Region



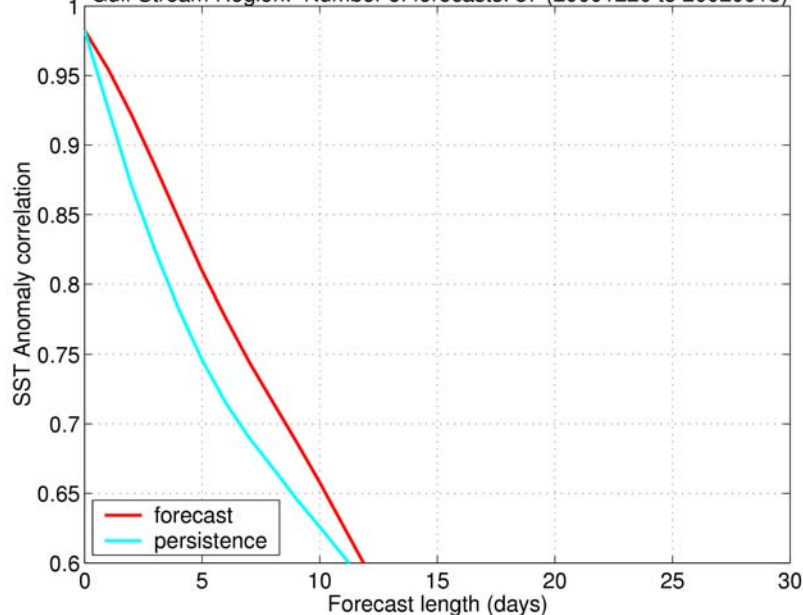
1/16° Global NLOM Forecast Skill

SST Anomaly Correlation (mean over 87 forecasts)

Gulf Stream Region

(w128) Mean SST Anomaly correlation vs Forecast Length (interpolated monthly climatology)

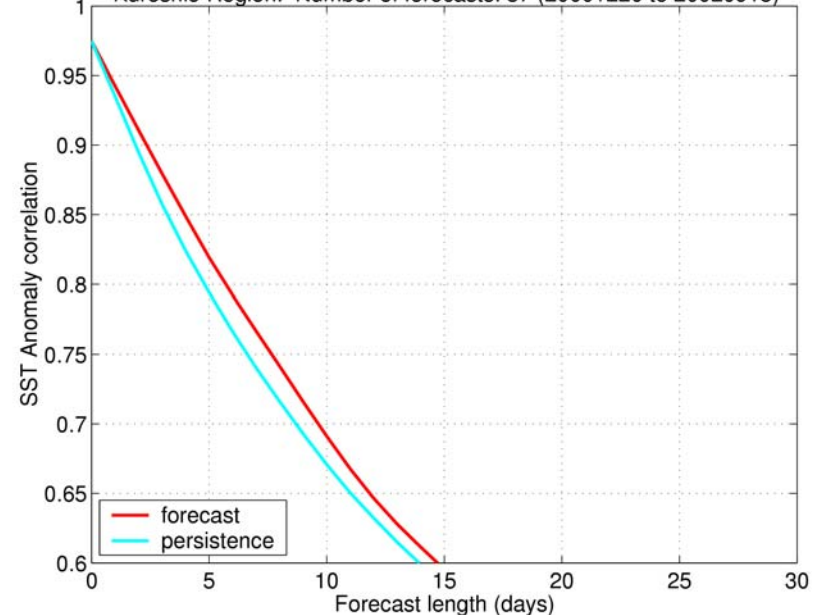
Gulf Stream Region: Number of forecasts: 87 (20001220 to 20020918)



Kuroshio Region

(w128) Mean SST Anomaly correlation vs Forecast Length (interpolated monthly climatology)

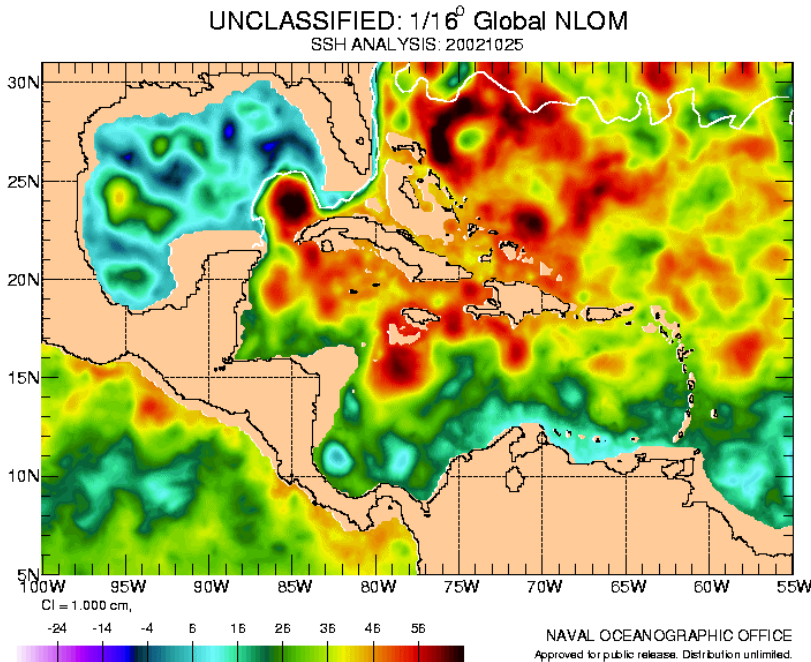
Kuroshio Region: Number of forecasts: 87 (20001220 to 20020918)



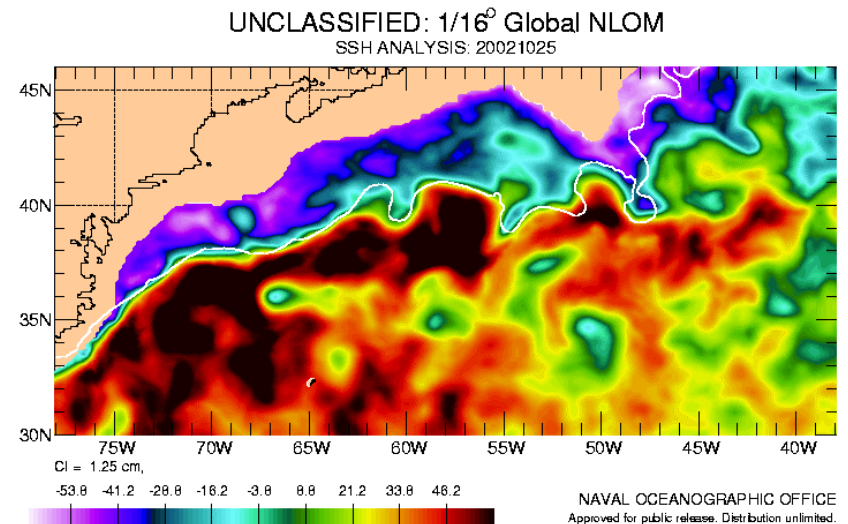
1/16° Global NLOM SSH

October 25, 2002

Intra-Americas Seas Region

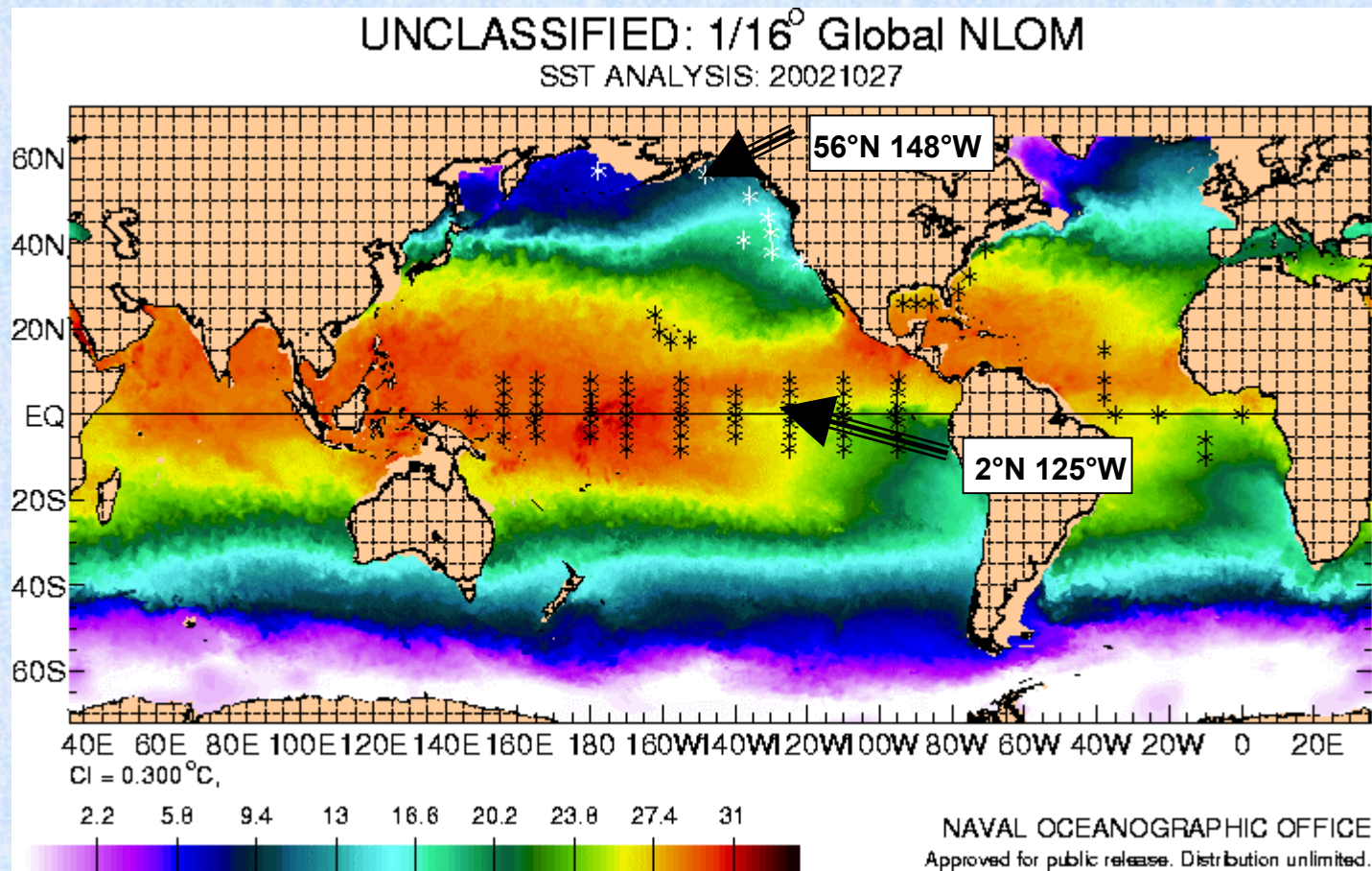


Gulf Stream Region



White line is the frontal analysis of MCSST observations performed at NAVOCEANO.

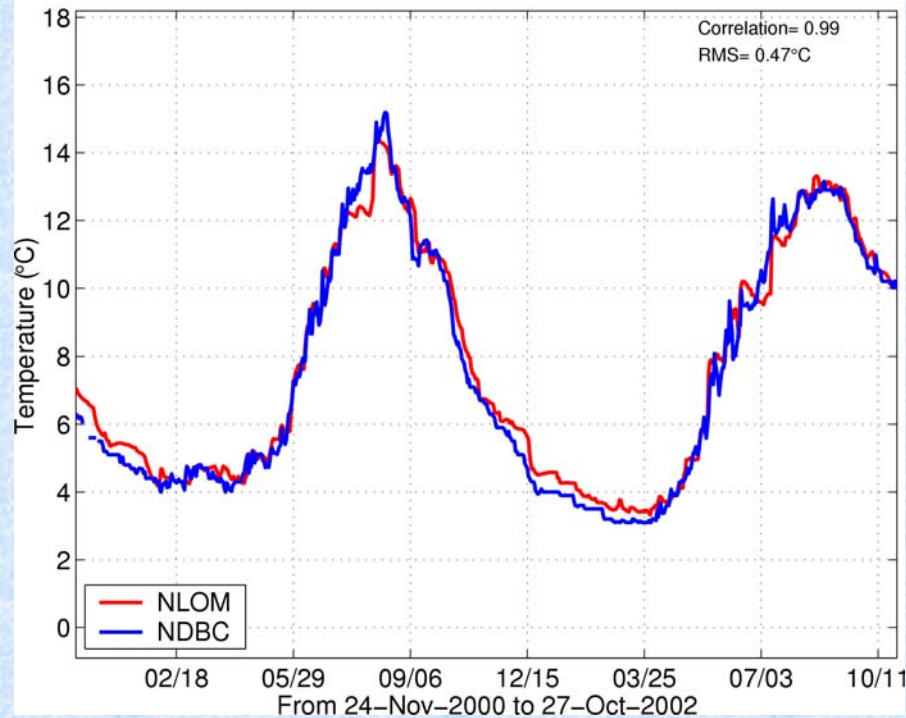
SST buoy locations overlaid on the 1/16° Global NLOM SST field for 27 October 2002



Comparison between 1/16° Global NLOM SST and independent SST observations from buoys

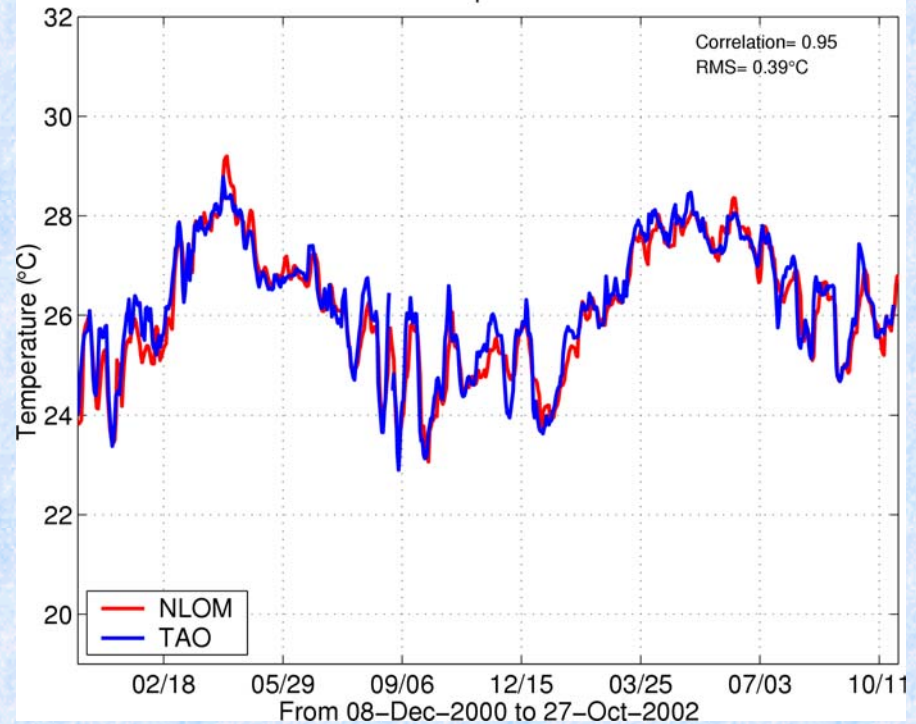
56°N 148°W

Sea Surface Temperature at: 56n148w



2°N 125°W

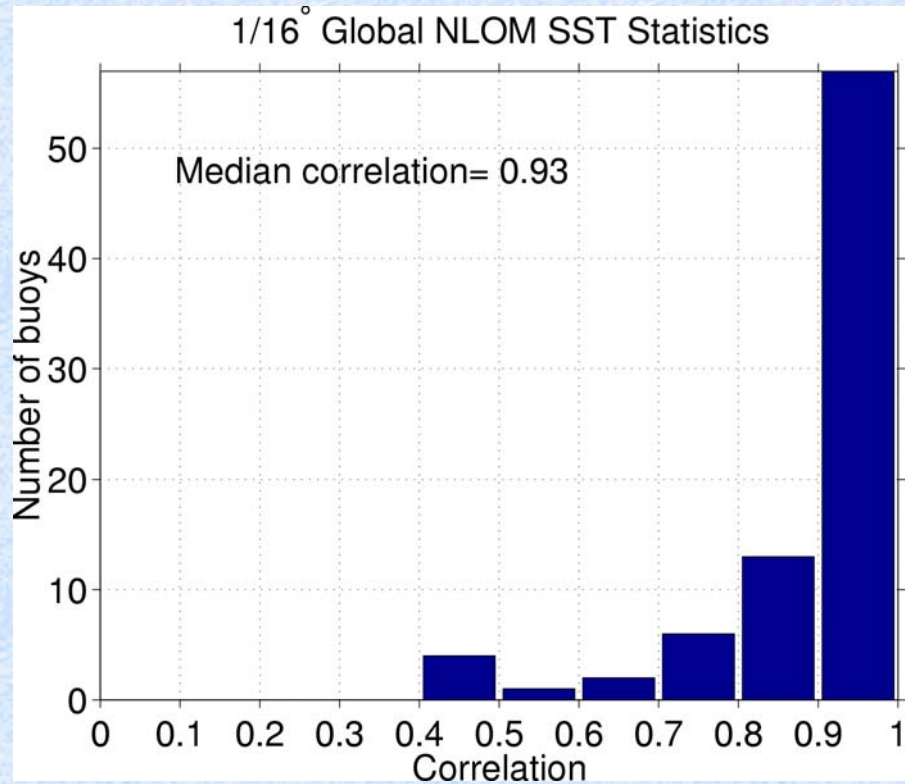
Sea Surface Temperature at: 2n125w



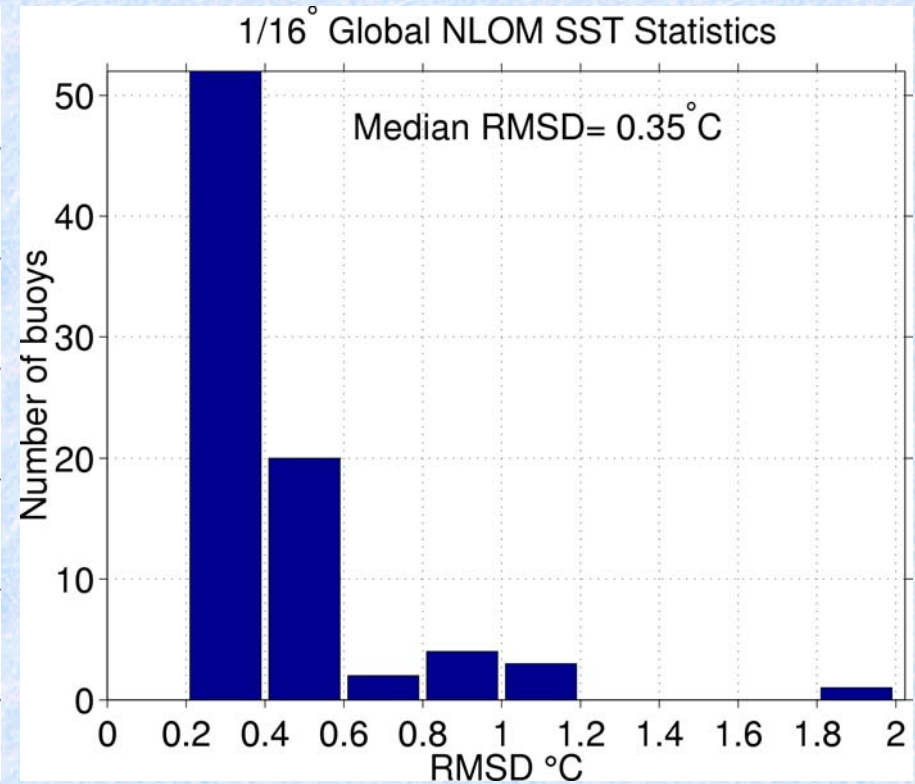
SST buoy comparison statistics

83 unassimilated buoys

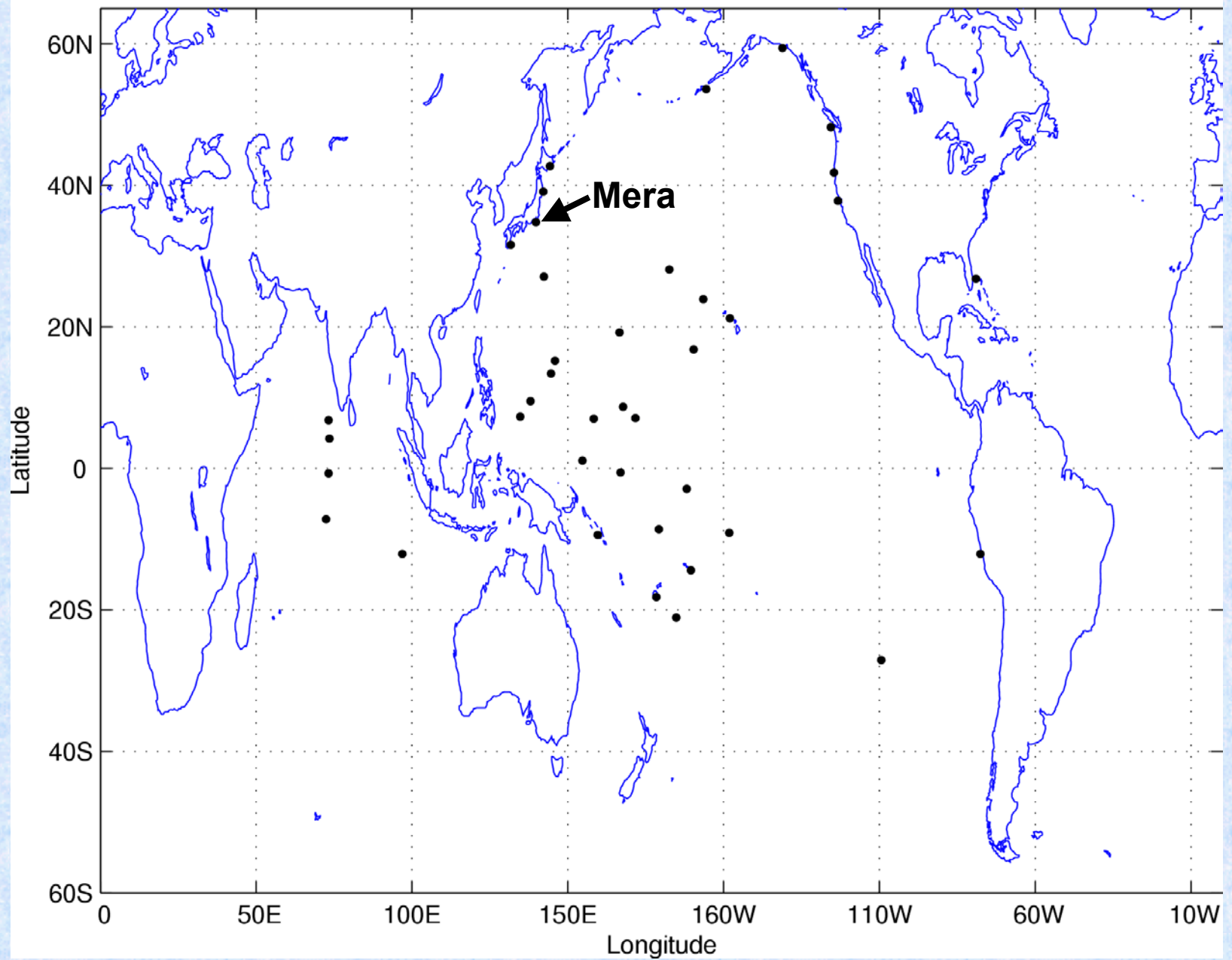
Correlation



RMSD



Positon of tide gauges

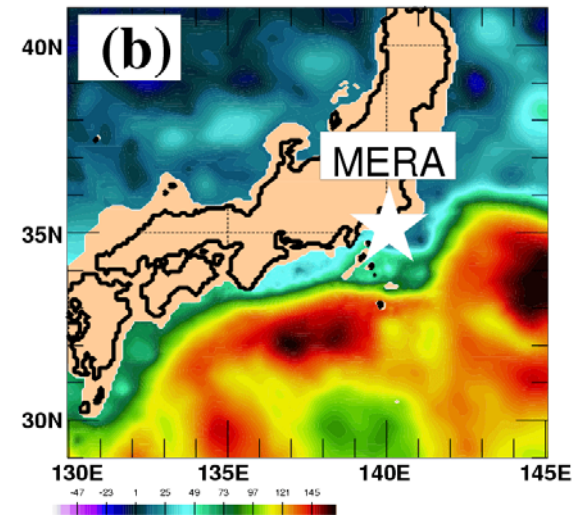
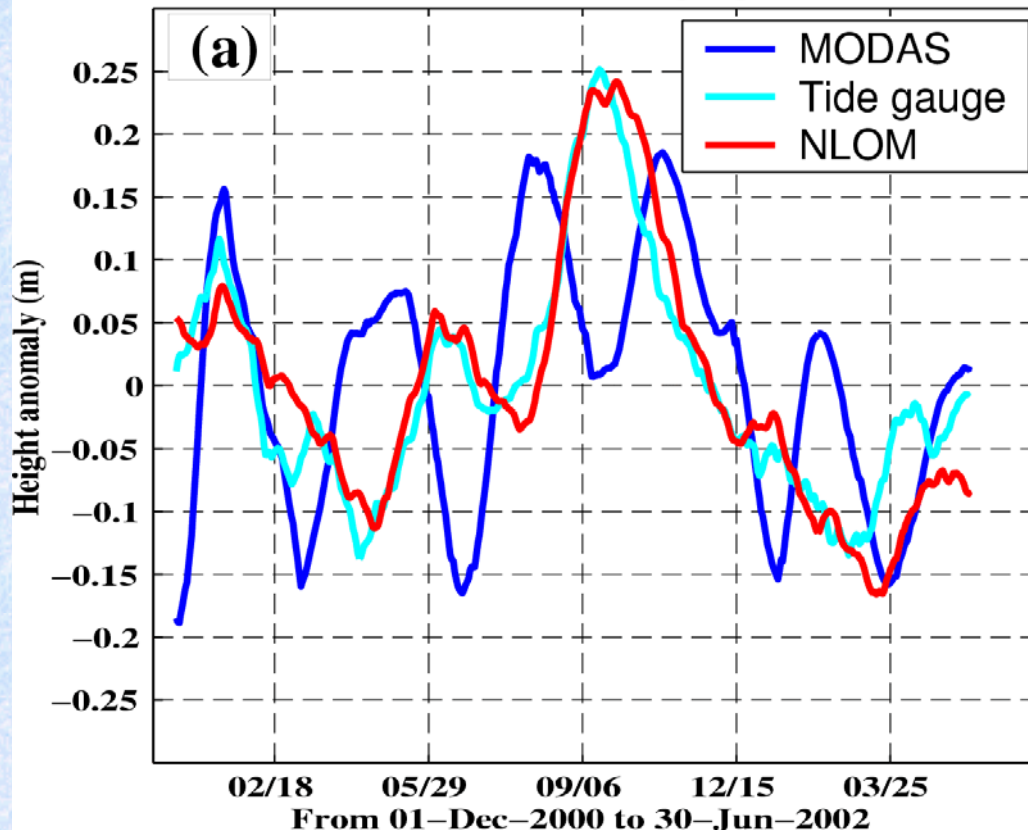


Tide gauge comparison

(30 day running mean)

MERA, JAPAN

NLOM: 34.81°N, 139.80°E Tide gauge: 34.92°N, 139.83°E



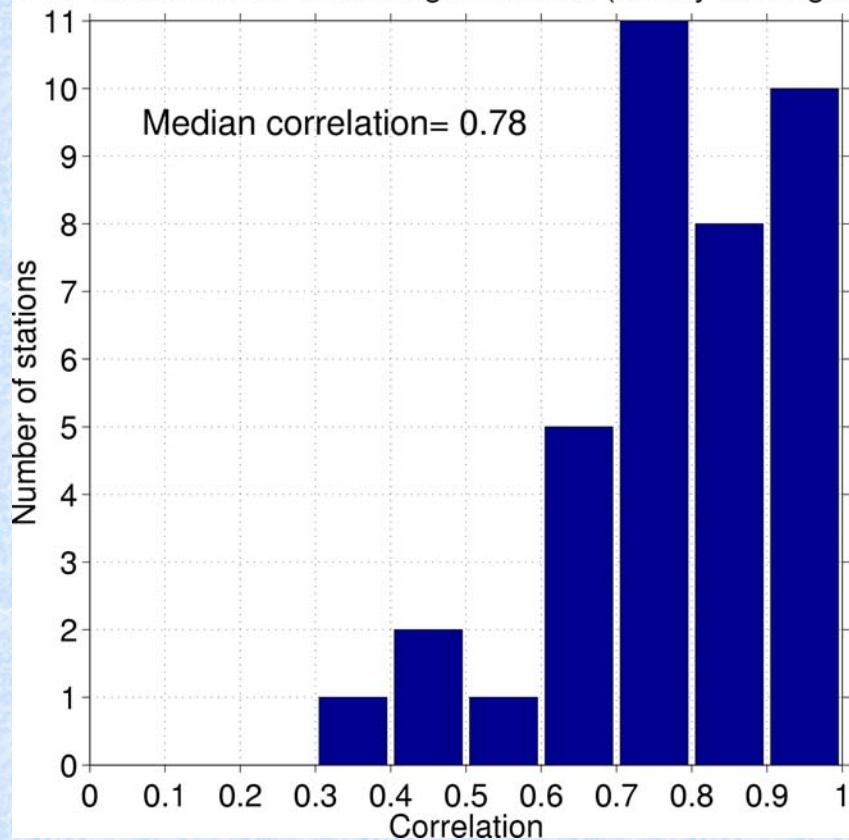
	r	RMSD (cm)
OBS & NLOM	.93	3.6
OBS & MODAS	.36	10.6
NLOM & MODAS	.38	11.0

SSH tide gauge comparison statistics

39 unassimilated stations

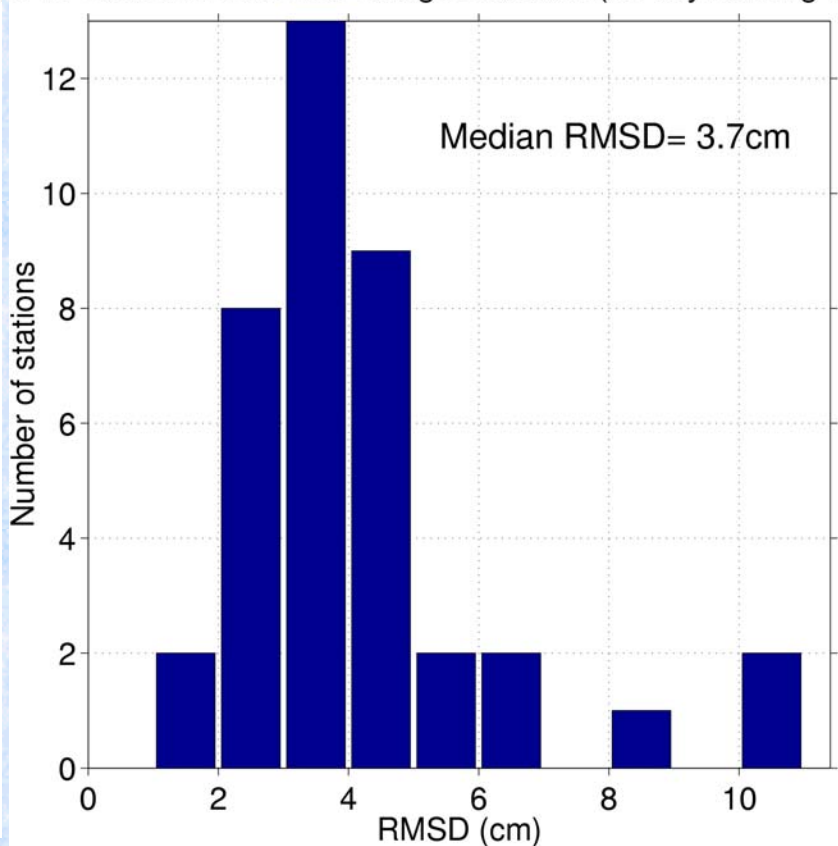
Correlation

1/16° Global NLOM Tide Gauge Statistics (30 day running mean)



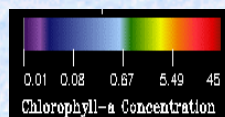
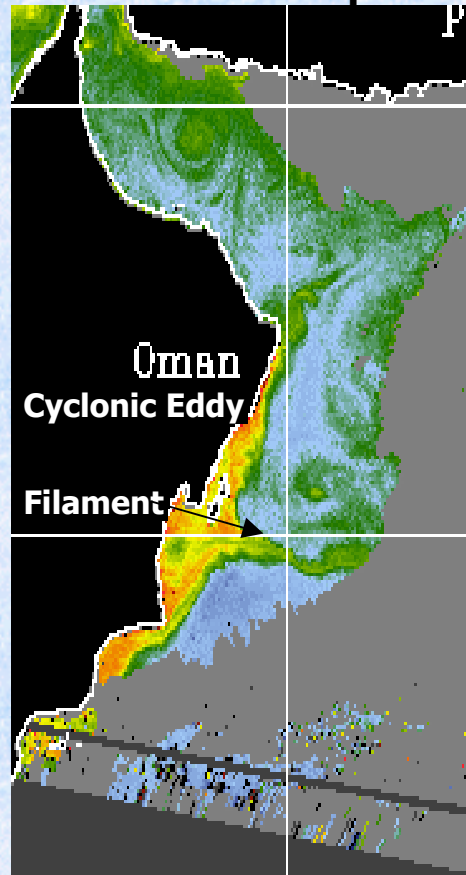
RMSD

1/16° Global NLOM Tide Gauge Statistics (30 day running mean)



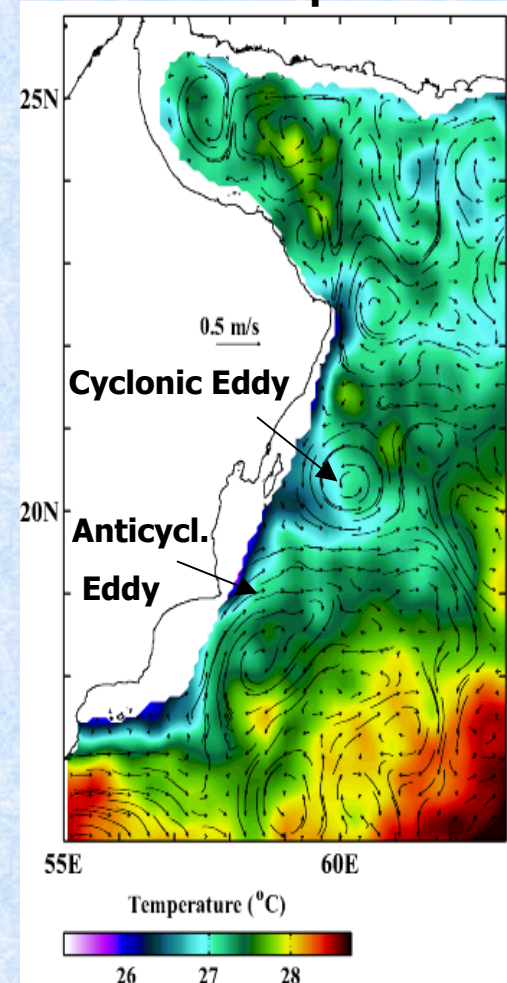
Oman Coastal Filaments During Spring Intermonsoon Comparison of SeaWIFS and NRL Real Time Models

SeaWIFS: 19 Apr. 01



Chlorophyl from SeaWIFS

NLOM: 19 Apr. 2001



Model SST and Surface Currents

Surface fields available on the anonymous ftp server

**ftp7300.nrlssc.navy.mil
cd pub/smedstad/dailyout**

Nowcast (last 4 days kept on ftp site)

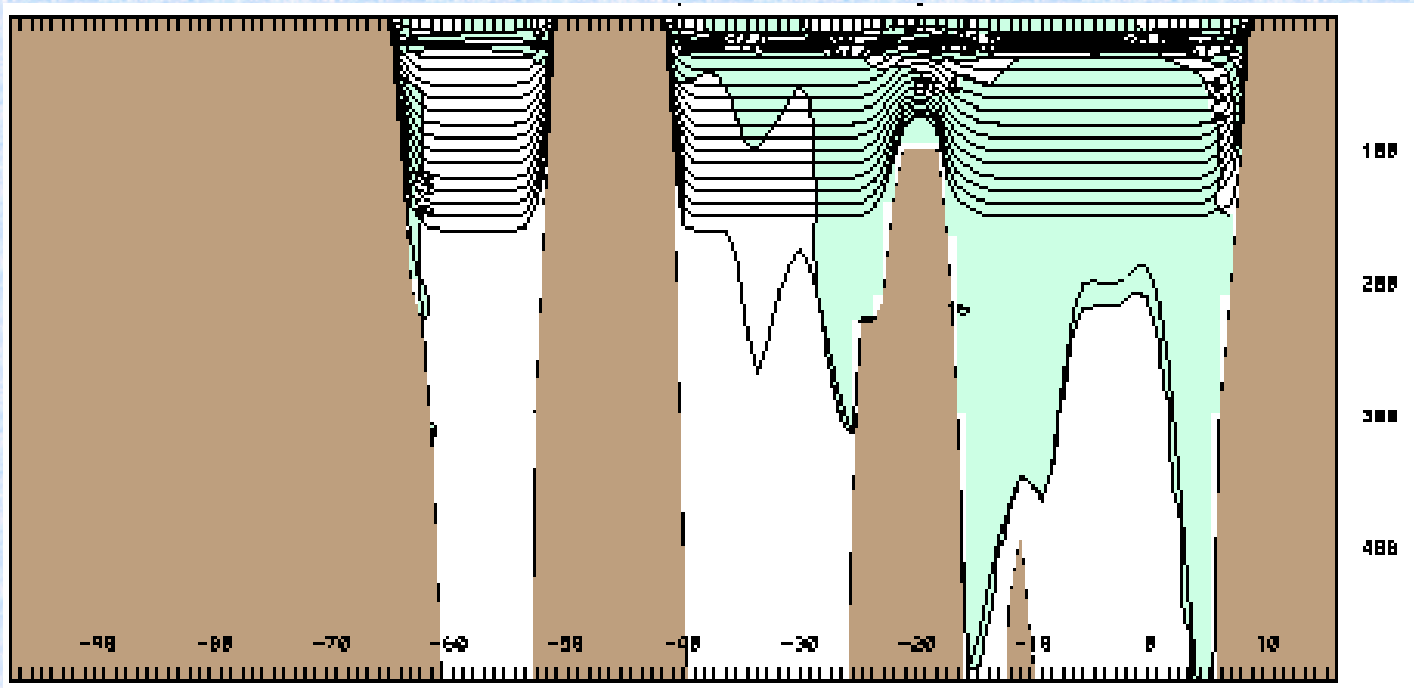
Last 30 day forecast (7, 14, 21 and 28 days forecast)

HYCOM

- A multi-institutional effort on the development and evaluation of a data-assimilative hybrid isopycnal-sigma-pressure (generalized coordinate) ocean model (called Hybrid Coordinate Ocean Model or HYCOM.)
- The partnering organizations are the University of Miami/RSMAS, the Naval Research Laboratory (NRL), NOAA/AOML, the Los Alamos National Laboratory, the Service Hydrographique et Océanographique de la Marine (SHOM), NAVOCEANO, Planning Systems Inc., Orbital Image Corp., and the U.S.Coast Guard.

HYCOM

The hybrid coordinate is one that is **isopycnal** in the open, stratified ocean, but smoothly reverts to a **terrain-following** coordinate in shallow coastal regions, and to **pressure** coordinate in the mixed layer and/or unstratified seas.



HYCOM

The primary computational goal is the establishment of a global eddy-resolving real-time ocean forecast system with sophisticated data assimilation techniques that can be efficiently executed on massively parallel computers

- 0.08° fully global ocean prediction system transitioned to NAVOCEANO in 2006**
- Increase to 0.04° resolution globally and transition to NAVOCEANO by the end of the decade**

HYCOM

Present near real-time system

- **1/12° Atlantic version of HYCOM**
- **Assimilation of the Modular Ocean Data Assimilation System (MODAS) optimal interpolated SSH anomalies from satellite altimetry**
- **Vertical projection of the surface observations by Cooper-Haines (1996, JGR-O)**

Assimilation in **HYCOM**

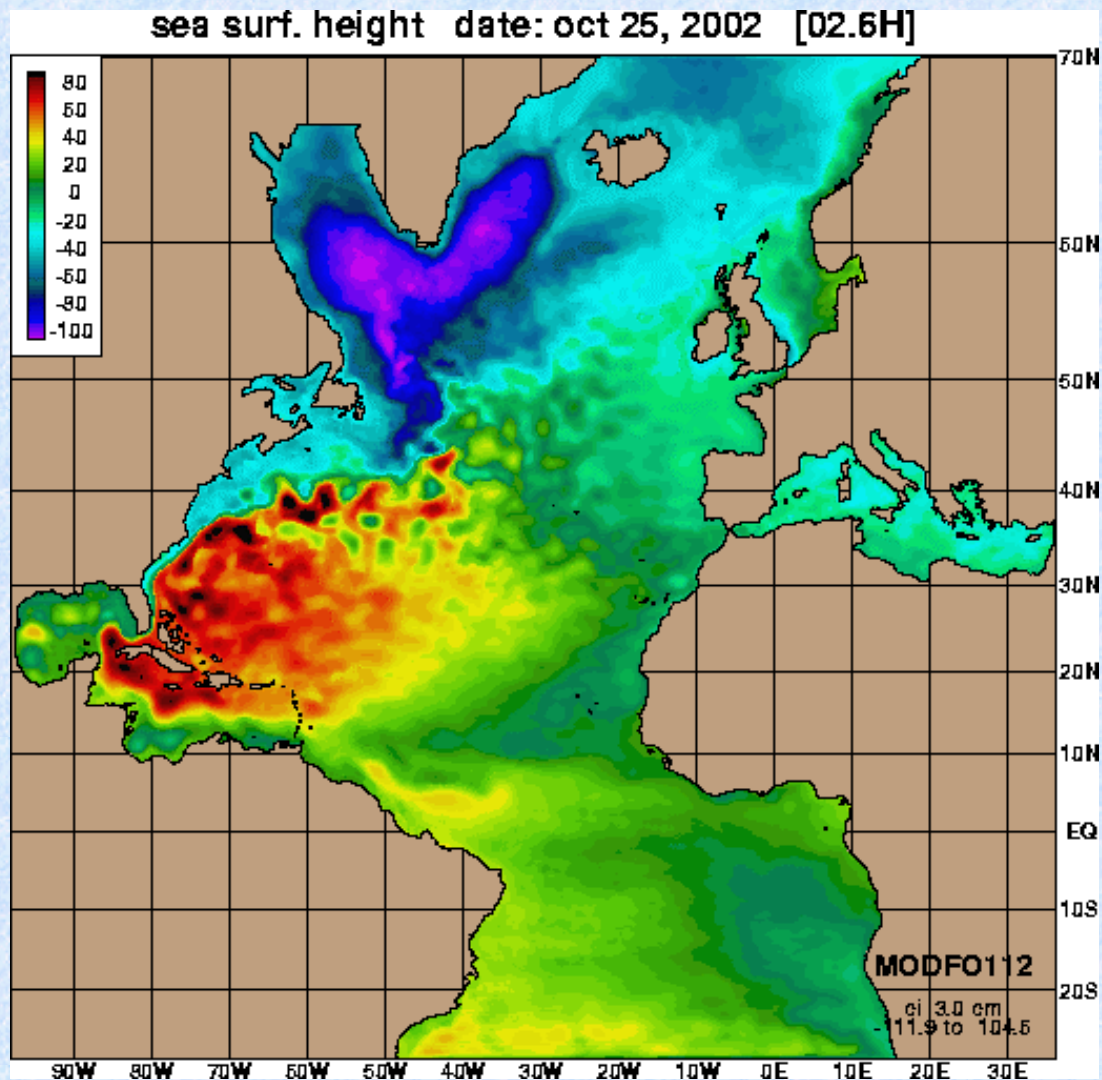
- **Several groups are working on the implementation of different assimilation techniques in HYCOM**
 - **Ensemble Kalman filter**
 - **Singular Evolutive Extended Kalman filter (SEEK)**
 - **Adjoint for HYCOM is being developed**

Atlantic Model Configuration

- **Horizontal grid: $1/12^\circ$ (1678 x 1609 grid points, 6 km spacing on average)**
- **28°S to 70°N (including the Mediterranean Sea)**
- **26 vertical coordinate surfaces (σ -theta reference)**
- **Bathymetry: Quality controlled ETOPO5**
- **Surface forcing: wind stress, wind speed, heat flux (using bulk formula), E-P + relaxation to climatological surface salinity**
- **River runoff included**
- **Buffer zone: $\sim 3^\circ$ band along the northern and southern boundaries with relaxation to monthly climatological T and S (Levitus)**

1/12° Atlantic HYCOM

25 October 2002

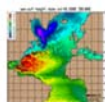


HYCOM Consortium for Data-Assimilative Ocean Modeling

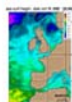
Near Real-Time Ocean Analysis and Modeling

1/12° Atlantic HYCOM Nowcast/Forecast

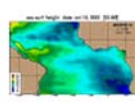
2002 Oct 22 Tue 16:29:36 CST



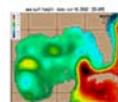
Atlantic



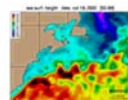
East Atlantic



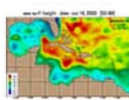
Equatorial
Atlantic



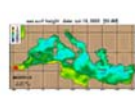
Gulf of Mexico



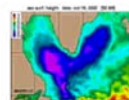
Gulf Stream



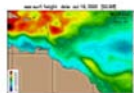
Intra-Americas
Seas



Mediterranean



Northwest
Atlantic



North Brazil
Current

Temperature and Salinity sections

For independent comparisons with unassimilated real-time in
situ data [click here](#)

*This site was created and is maintained
by Ole Martin Smedstad
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*Jan M. Dastugue
Naval Research Laboratory
Stennis Space Center, MS*

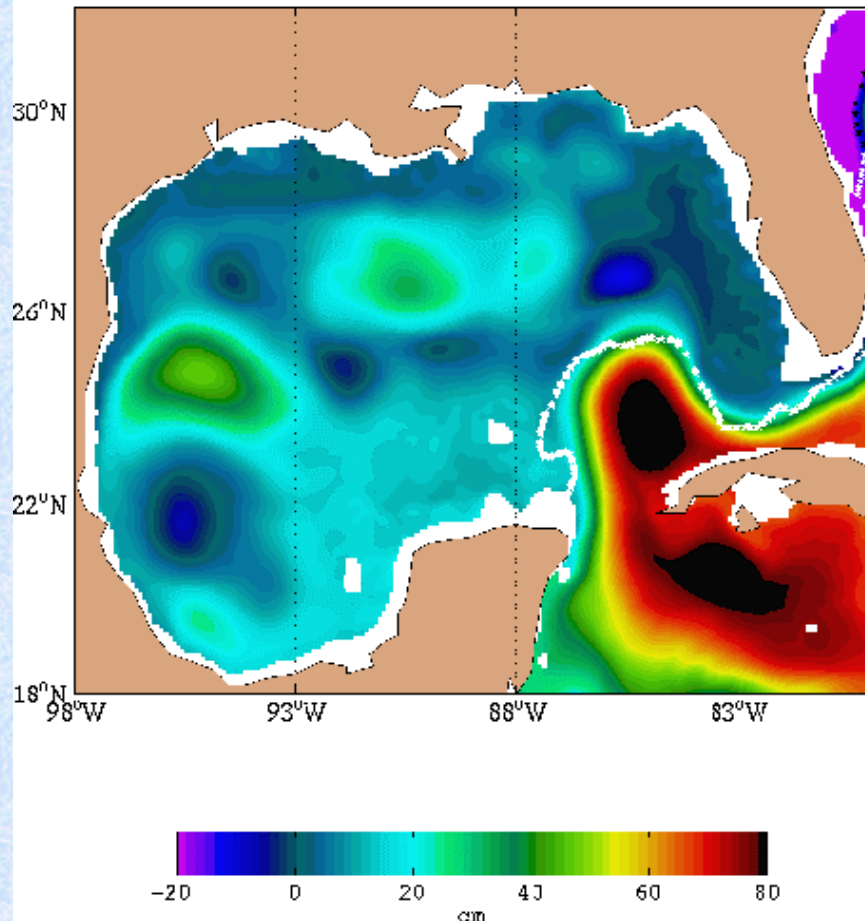
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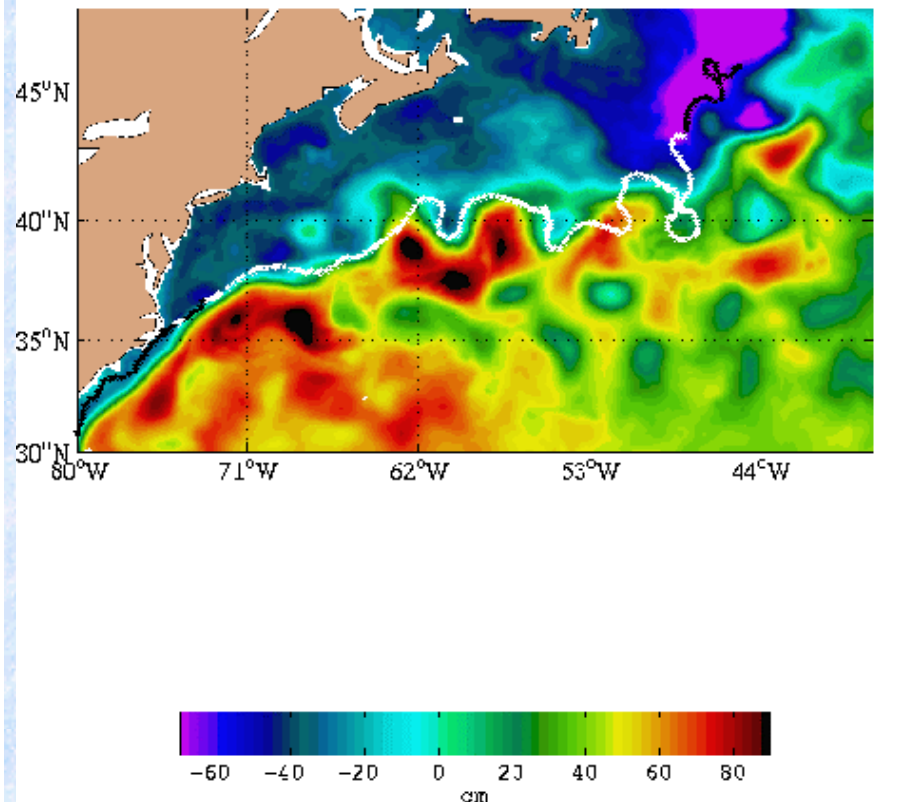
This page was last updated 27 June 2002.

1/12° Atlantic HYCOM SSH 25 October 2002

SSH 1/12° HYCOM (MODAS+1/12° MIC) 20021025



SSH 1/12° HYCOM (MODAS+1/12° MIC) 20021025



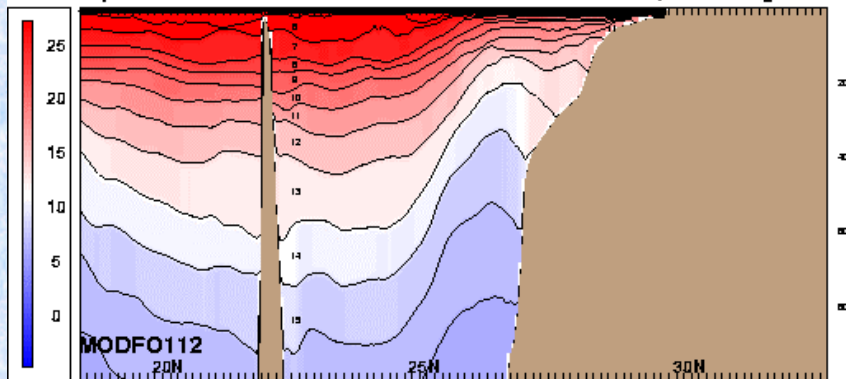
White/black line is the frontal analysis of MCSST observations performed at NAVOCEANO. Black line represents data more than four days old.

Vertical section of temperature and salinity in the Gulf of Mexico

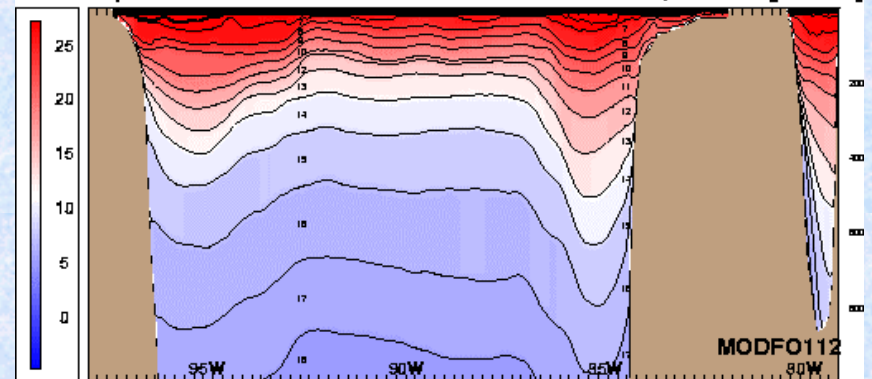
1/12° Atlantic HYCOM 25 October 2002

North-South section along 84.88W **East-West section along 25.08N**

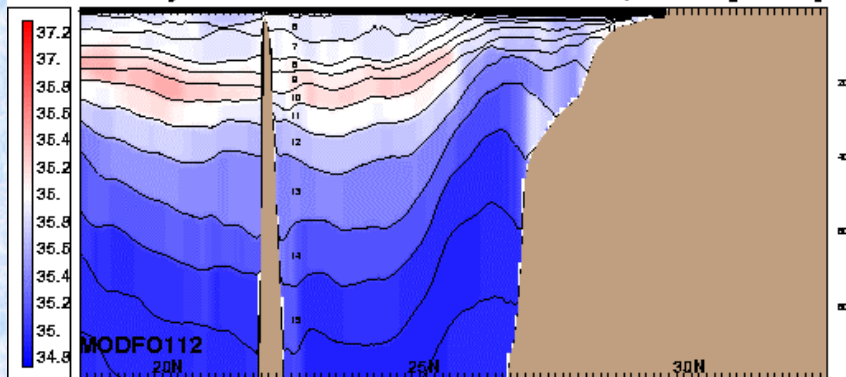
temperature merid.sec. 84.88w date: oct 25, 2002 [02.6H]



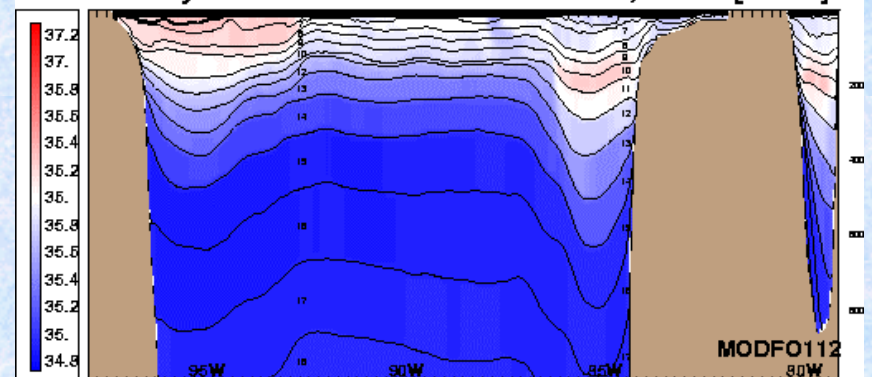
temperature zonal sec. 25.08n date: oct 25, 2002 [02.6H]



salinity merid.sec. 84.88w date: oct 25, 2002 [02.6H]



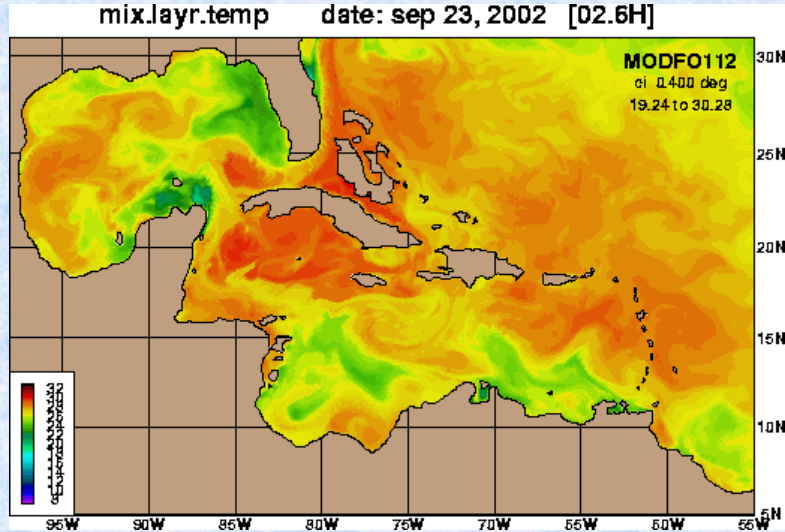
salinity zonal sec. 25.08n date: oct 25, 2002 [02.6H]



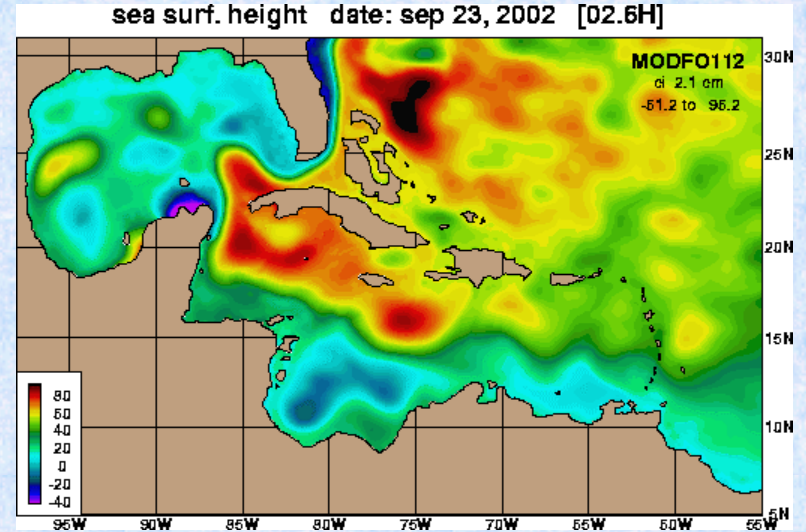
1/12° Atlantic HYCOM

Tropical storm Isidore, 23 September 2002

Mixed layer Temperature



Sea Surface Height



Real-time 1/16° NLOM web page:

http://www.ocean.nrlssc.navy.mil/global_nlom

Real-time 1/16° NLOM surface data:

<ftp7300.nrlssc.navy.mil>
[cd pub/smedstad/dailyout](ftp7300.nrlssc.navy.mil/pub/smedstad/dailyout)

HYCOM web page:

<http://hycom.rsmas.miami.edu>